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ABSTRACT

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COMPUTER EDUCATION IN A DEVELOPING COUNTRY

H. K. Kesavan

A. Summary

The paper deals with computer education in India at the university level. The principal causes which are inhibiting expansion of educational programmes are first outlined and suggestions offered for achieving a better performance which is entirely feasible within the resources of the nation. The philosophy underlying the paper is that transfer of technology in the computer field, like in many other fields, can only be accomplished when the recipient country designs the proper "matching impedance" to ensure the transfer to occur from the donor country. The "matching impedance", in this instance, consists mostly of reorganisation of administrative structures of university computer centres and a proper reallocation of existing resources. When these preconditions for growth are established, the universities will be in a position to expand computer education quite rapidly and a concrete proposal is made in order to achieve this goal. The paper concludes with a discussion of the type of assistance that would be necessary to accelerate the process.

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B. Introduction

1. There is increasing awareness in the country that computers could be used for accelerating national development and effecting social change. But this appreciation remained only in symbolic terms till such time that computer consciousness reached a critical threshold which has occurred only recently. Some of the inhibitory causes are outlined.

2. India had only 4 - 5 computer systems till 1963 and at present the total has reached 111. The educational institutions have only 14 computers out of a total of 111, a deplorably low figure considering the real needs in education.

3. A good number of computers made their way into industries mainly for accounting purposes. Part of the blame should rest on the sales organizations which pursued the unenlightened policy of marketing their products based primarily on the appeal that computers constituted a better alternative to unit record equipment. The emphasis was never placedon increasing productivity, managerial assistance etc. This resulted in a situation where the labour unions started offering resistance to installation of computers because they were viewed as mere labour-saving devices.

4. The foreign exchange crisis has also led to a situation where the customers have very little choice overy buying systems which would meet their specifications. Even the limited choice is quite often pre-empted because the decisions are often made by people who are not particularly knowledgeable in the field (vice-chancellors, for instance) and what is worse, who are not willing to consult experts. The Computer Society of India has publicised the fact that they would be willing to render free service on the choice of computer systems to meet customer specifications, but until one year ago there was no request for such service. The tendency to depend on the sales organisations for such advice has only compounded the difficulty.

5. The rate of increase of computers that is envisaged in India is faster than what the country could cope with in terms of her foreign

exchange resources. Great stress has therefore been laid on indigenous production of computers (see appendix 1). Commendable as these efforts are, the demand for more computers, however, cannot be postponed until such time the nation attains a degree of self-reliance in this respect because it is precisely to hasten national development and social transformation that the country needs more computers right now. Import of computers seems inevitable in order to meet the immediate needs but, given the country's financial situation, this flow will by necessity be limited and hence the choice of systems becomes very critical.

A country as big as India is tempted to set self-reliance as a goal in all her technological endeavours. But it is doubtful whether total self-reliance should even be attempted in the field of computers. Based on the experience of even the developed countries, it seems reasonable to hypothesize that India would be better off to restrict her indigenous production to the types mentioned in appendix 1. Even this list appears to be rather ambitious in view of the current slender base of the electronics industry.

C. University Computer Centres

6. There are at present 14 computer systems in universities out of a total of 111 in the country. The word university here is meant to include all educational institutions. The biggest of these are (a) a CDC3600 system in Tata Institute of Fundamental Research, Bombay, and (b) an IBM7044 system at Indian Institute of Technology, Kanpur. These, in fact, are the biggest systems presently available in the country.

7. The computational demands of universities and other technological institutions are increasing at a rate that the present installed capacity is grossly inadequate to meet the real needs. The difficulty is augmented by the fact that none of the non-university computers are accessible for educational purposes. Yet, at the same time, there are serious inhibitory factors for a maximum usage of the existing university computers.

8. The tendency to regard a computer as mere equipment and thus as a

specific research tool and not as a facility has led to a situation where these have become the private property of university departments which initiated the request for their purchase. Even other departments within the same university find it difficult to have access, let alone students from other universities with the sad result that the versatile educational possibilities of the facility are severely stifled.

9. The fact that even a small machine could be put to immense educational use has been demonstrated in the Indian Institute of Technology, Kanpur. Apart from training a large number of undergraduate students every year (nearly 300), the IBM1620 (Model 1) there was used to spread computer consciousness in India by means of periodic intensive courses (see appendix 2). In fact, the success of the Kanpur experiment constitutes an existance theorem that even with a small computer one could organise a large computer centre to serve educational needs.

10. The equipment-based view existing in several university computer centres has, unfortunately, inhibited the possibilities of assembling good teams of soft-ware people to operate them as educational centres in the true sense of the word.

11. Even the enlightened university computer centres find it difficult to have good soft-ware teams because the existing university structures do not allow for senior positions in the ranks of soft-ware experts on par with professional appointments. Quite often the best of soft-ware people do not necessarily possess high academic qualifications and their academic distinction can hardly be comprehended by the conventional system of rewards prevailing in the universities. Consequently, many key software people refuse to accept second-class citizenships and leave the university to take up jobs in industry where they can expect to increase their incomes. Unless this situation is rectified, there is very little job propensity in the university computer centres to attract competent systems people.

12. Because of the predeliction to view computer costs as primarily capital costs, scant attention is paid to make the operation of computer centres financially viable. Unless the cost-accounting procedures emphasize the operational cost aspect of computer usage, it presents a serious impediment

for proper growth.

13. In view of the above discussion, it can be concluded that the present dilemma in computer education is not merely due to lack of resources but, more importantly, due to methods of allocating resources. These problems do have feasible solutions and the country should sort these out without any external aid. The cause of computer education in the country will not be served by merely increasing the number of university computer centres without successful efforts to change the status quo.

D. Recommendations

14. The University Grants Commission, and Department of Education and other governmental agencies concerned with education should take steps to alleviate the present problems. This is entirely within their purview because they control all the financial inputs to the universities. The presently installed capacity, meagre as it is, should be fully utilised for educational and research purposes.

15. The computer demands of universities in India cannot be met by the existing capacity, nor is it economically feasible to provide all the universities with individual computing facilities. Furthermore, proliferation of small-scale or medium-scale batch processing systems do not take into cognisance the modern developments in computer technology and computer education. Some radical solution is necessary if India has to tide over the crisis in computer education.

16. In order to meet the situation, it is proposed that four university regional computer centres be set up in the country. The criteria for the choice of locations should take into account proper geographical distribution and also the vicinity of these centres to educational institutions which have already demonstrated their competence in the field of computer education. In fact it would be ideal if these centres were to be located on the premises of the latter institutions hereafter referred to as sister universities. (This may be politically awkward to implement but the times call for bold decisions).

17. The computer systems should be of the large-scale variety capable of time-sharing facilities. It is recognised that at present the efficiency of data links is not quite up to the mark for achieving reliable communication but the situation is improving very fast in this respect.

18. The universities in the region should be provided with remote-terminal facilities and other peripheral equipment which are necessary for establishing a time-shared environment. These institutions should also establish computer centres with proper academic inputs into them and not merely strive to create a service facility.

19. The regional centres should be established as autonomous bodies but they must possess organic connections with their respective sister universities. Great care should be bestowed on the administrative structure of these centres because they do represent an unique opportunity in India. In fact, an enlightened administrative structure of the Centre can have an impact on the inherited administrative structure of the sister university.

20. The regional centres should be run on a business-like basis. With the size of operating budgets that could be envisaged for a successul centre, the day-to-day administration of it should not be imposed on a professor as was the practice in the days of managing a relatively small computer centre. However, since education and research are the twin goals of the centre, the administrative set up should envisage having academic people in policy-making bodies.

21. Apart from serving the internal educational programmes in computer sciences, the regional centres, in partnership with sister universities, should embark on educational programmes to train people and these need not be restricted to universities alone. The type of programmes implemented by IIT/Kanpur (see appendix 2) should be greatly intensified.

22. Given any geographical distribution of the centres, it may not be possible to bring all the universities within their compass. For students in these universities, the regional centres (or the sister universities)

should organise "computer camps" on the model of "survey camps" which is a time-honoured method in the Civil Engineering profession.

23. The creation of the regional centres should not preclude universities from doing their own special purpose computation which are research oriented; computer graphics, for instance. The idea of the regional centres is not to create monsters which inhibit the growth of individual centres based on merit and performance.

24. The major brunt of the resources, human and material, for the successful operation of the centres should be borne by the country itself. That computers could be instruments of change has assumed the proportions of an article of faith in the country and consequently it is imperative that the forces of change are generated from within the country to the maximum extent possible.

25. It would be of immense assistance to India, if she receives aid to import the computer systems to the regional centres and other peripheral equipment for establishing the time-shared environment. Since the latter is a relatively new experience even in North America, technical assistance from such professional organisations such as ACM, IFAC, etc. would be most beneficial.

September 30, 1969

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APPENDIX 1

RECOMMENDATIONS OF THE ELECTRONICS COMMITTEE ON THE REPORT OF ITS WORKING GROUP ON COMPUTERS

The Current Picture

1. There are, at present, 111 computer systems functioning in India with a nominal book-value of Rs. 20.3 crores (predevaluation). Of these systems, 42 (Rs. 8.4 crores) are with government departments and public sector concerns, 42 (Rs. 6.85 crores) with the private sector, 13 (Rs. 2.96 crores) with R & D organizations, and 14 (Rs. 2.09 crores) with educational institutions. (See Table III on page 27)

2. This picture is very far from ideal and, in fact, in several respects, is quite the reverse of what is needed to make the maximum impact in computer usage. Except for a minority of installations, all the others are restricted, more or less seriously, in what they can offer by way of services to a wide class of users. The high proportion of investment in a rather narrow group of commercial data processing systems, and the concentration of these in agencies which limit their accessibility to outside users, both have a tendency to affect adversely the spreading of computer consciousness in the country. The investment in computers in the educational sector, in scientific and research organisations, and in service centres with educational and training facilities, is very poor. Since these are the sectors where the availability of the right computer system is likely to have the maximal national impact, this imbalance is all the more to be deplored.

Indigenous Manufacture

3. It is our view that all computer systems requirements except the large and very large systems, should be met through indigenous manufacture. We feel that it is essential to attempt this task and that it is feasible to reach this goal of attaining self-sufficiency in the small and medium size computer systems within the next 5-10 years. As currently envisaged, the production programme of IBM, ICL/BEL and ECIL, while they seem prima facie to be capable of meeting the projected requirements, the first two depend heavily on imported sub-systems, modules and components which the lowest import content is that of ECIL, it being about 15% of system cost.

4. Upgrading these production plans consists in accomplishing two things. The first is upgrading the quantity of production. The second, by far the more important from the longterm point of view, is upgrading the indigenous capability in the design, development and manufacture of components and sub-assemblies. Our overall strategy should be to become reasonably completely self-sufficient in the design and fabrication of at least some of the more critical sub-assemblies. With this in view, we make the following specific recommendations:

5. IBM production plans should be "modernised" to deal with 360 series systems (models 20, 30, 40 and 50 covering the small to medium range) and not 1400 series systems.

6. ICL production plans should restructured to lay greater emphasis on 1902A and 1903A (rather than 1901A) central processor with larger (16 to 32K) core memories and more (4 to 8) tape units, taking the currently envisaged volume of Rs. 2 crores to Rs. 10 crores in the Fourth Plan Period. At least the Deference requirements for general purpose computers in the 4th Plan period must be placed as firm orders to make this possible.

7. ECIL production plans for realtime computers should be diversified to embrace a larger family of closely related central processors with a range of memory capacities, to cater to applications in message switching, satellite communications, etc.

8. The highest priority should be given for reaching 100% self-sufficiency (or as close to it as practicable) during the 4th plan period in the manufacture of the following:

i. Digital logic IC modules and discrete active components for computer use.
ii. Ferrite cores for memory planes.
iii. Console typewriters.
iv. Magnetic tapes for computer use, and line printer ribbons.
v. Hardware items such as glass epoxy laminates, wires and cables, neon indicators and nixie tubes, relays and microswitches, multipin card and cable connectors, etc.

9. Of these, items (1) and (5) are in various stages of development in the country and plans for production by various groups under collaboration are also under exploration. Various ad-hoc groups for the Electronics Committee have prepared comprehensive lists of standardized specifications for these items. It is essential to press vigourously ahead with the implementation of programmes for starting production of these in amounts that are likely to be needed.

Software Production

10. A computer system is only as versatile as the software that is made available with it. Sophistication in software has grown so enormously in the past decade, that it is estimated that in the computer systems of the 1970's, the hardware to software cost is likely to be in the ratio 30:70. Currently, it is roughly 50:50, and a decade ago it was 70:30.

11. An important feature of software development is that it can be farmed out to several organisations. Like core-stringing, this is also a labour intensive activity except that it requires intellectually skilled manpower. Except for the salaries of the staff and frequent access to a system for which the software is being developed, the activity requires very little overheads. Thus, contracting for software development would seem to have very high employment potential in a country like India. Software business enterprises could be grown with great advantage and profit to function as satellites to the larger systems manufacturing agencies. Again, as mentioned earlier in the case of core-stringing, export potential, as well as the value added, in the case of software manufacture is very large. An investment in development software capability and marketing would be well worth and would have export potential.

In-house Systems Groups:

12. In developing indigenous capability in the field of computers including both hardware and software, the acceptance at the very outset, of the principle that systems engineering responsibility will remain the the hands of Indian engineers can greatly accelerate the advance of an indiginous computer industry. This is because even if it is impossible to be self-sufficient in all the items which are involved in a given computer system, adoption of this approach makes it possible to fully utilise those items which are available locally. Moreover, it also permits costs-effective optimisation in the purchase of those components and sub-assemblies which may have to be imported. A further point is that in many computer applications interfaces between sub-systems and between the computer as a whole and other units are involved. This necessitates the provision of interface electronics, the near complete design and fabrication of which can be carried out indiginous only if systems engineering is handled by Indian Groups.

13. These groups should have the competence to translate user requirements into hardware and software needs and to be able to advise the manufacturing units on the one side, and the R & D and D & D units on the other side, as to what are required to be manufactured, in what time scales, in what quantities, and so on. Such groups should also be in a position to identify areas for forward-looking research likely to be of relevance to their parent organisations.

Data Links

14. In the next 10 years, there is bound to be a growing demand in the country for reliable, fast, and cheap communication links for transfer of data between computers, between remote consoles (i.e. remote typewriters and printers) and computers, and between remote sensors/controllers (i.e. Data-acquisation equipment and controllers) and computers.

15. This aspect should be kept in mind while planning for the upgrading of communication technology in the country during the next decade.

Education Programme

16. Meeting these system requirements, as well as implementation of a manufacturing programme on the scale suggested, would need a vast amount of technical manpower trained up to various levels. It is essential to have a reasonable idea of this manpower requirement and ensure that our current educational and training programmes are adequate to meet this demand.

17. The programmer requirement, as estimated ranges from 3,000-6,600.

18. Over 1,000 maintenance engineers will be needed to keep all the estimates systems in full operation.

19. At the end of the 10-year period, with the full utilisation of all the estimated number of system, there should be in the country from 12-20 thousand active users knowing programming in some form.

20. In addition to the above, there is likely to be a need for large numbers (several hundreds) of design and development engineers, production engineers, and supporting technical staff, for system engineering, system fabrication, assembly, testing etc. in organisations, like the Defence Services, Communication agencies (satellite, telephone, telegraph) etc. A large amount of in-house expertise in these areas would have to be grown. This is likely to call for basic reorientation and modernisation of current training programmes in these organisations. Steps must be taken to start these modernisation trends at an early date.

21. Post-graduate (PG) training in the computer sciences is currently available only in a few places in India.

22. It is essential to start specialised M. Tech level programmes in the computer sciences and technology in all the IIT's and the major institutes of sciences. In the next 10 years there is likely to be a need for about 300 M. Tech's and 50 Ph.D's in the computer sciences and technology. In the IIT's, all undergraduate students should be encouraged to learn computer programming. IIT Kanpur has already initiated such a scheme. All research students (M.Sc. and Ph.D. in Sciences) in at least all the major Universities should be required to learn computer programming.

Research and Developing Funding

23. No country can expect to build up the level of R & D activity within its educational sector to any significant extent through the exclusive use of funds available within its education budget. The infrastructure needed for R & D work within the academic framework has to be paid for more or less completely through R & D contracts from user organisations.

Conclusions

24. A large number of fundamental problems that a developing country like India has to cope with in her daily living are problems connected with organisation and management.

25. Computers--large and medium sized ones--are indispensable to accomplish this. This is one of the principal conclusions of this report which we would like to emphasize.

26. A Computer Panel consisting of 4 or 5 persons should be constituted so that the Electronics Committee would have a resources group to whom it could refer any technical matter involved in the development of computers in India. (The names of the persons for the panel would be decided by the Chairman in consultation with Dr. Bhagavantam).

27. The Electronics Committee proposes to award developmental contracts for hardware and software development for major specific applications and these should stimulate acitivity by D & D groups in the field of computers, components, peripherals and software.

APPENDIX 2

Intensive Courses given by IIT/Kanpur

Year	Title	No. of participants
1963	Workshop on computers and planning October 12-13, 1963	20
	Computer training programme November 25--December 6, 1963	23
1964	2nd Intensive Course on Computation February 11-20, 1964	60
	3rd Intensive Course on Computation April 28 to May 7, 1964	43
	4th Intensive Course on Computation June 9-18, 1964	48
	Advanced Computer Seminar December 14-18, 1964	45
	Symposium on High Speed Computation December 20-21, 1964	150 (Approx.)
	Specialised training in programming the IBM 1620 computer April 1 to May 9, 1964	12
	Specialised training in programming the IBM 1620 computer September 21--October 31, 1964	12
	5th Intensive Course on Computation September 8-18, 1964	62 (incl. IITK)
1965	6th Intensive Course on Computation March 10-20, 1965	42
	7th Intensive Course on Computation July 14-24, 1965	55 (incl. IITK)
1966	8th Intensive Course on Computation Jan. 5-15, 1966	48
	9th Intensive Course on Computation July 27 to August 6, 1966	44
	Computer Methods in Power Systems Engineering December 19, 1966 to January 6, 1967 (in collaboration with EE Dept., IIT-Kanpur)	27

1967	10th Intensive Course on Computation May 10-20, 1967	79 (incl. IITK)
	11th Intensive Course on Computation Oct. 16-26, 1967	54 (incl. IITK)
1968	12th Intensive Course on Computation July 22, 1968 to August 1, 1968	74 (incl. IITK)
	Operations Research and Computer Methods (in collaboration with Indian Institute of Management, Calcutta)	28
	13th Intensive Course on Computation November 11-21, 1968	65 (incl. IITK)
1969	14th Intensive Course on Computation April 2-12, 1969	47 (incl. IITK)
	Computer Methods in Control Systems Engineering May 5 to June 1, 1969	19

MEETINGS AND CONFERENCES

1967	2nd Annual Meeting of the computer Society of India December 11-13, 1967	40
1969-70	15th Intensive Course on Computation August 20-30, 1969	52
	Advanced Course in Systems Programming Sept. 15-Oct. 11, 1969	20 (approx.)
	Course on Decision Tables in Systems Analysis and Computer Programming	20 (expected)
	16th Intensive Course on Computation November 19-29, 1969	55 (expected)
	17th Intensive Course on Computation March 18-18, 1970	55 (expected)
	Operations Research and Computer Methods February 5-25, 1970	25 (expected)